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DWIGHT H. GREEN, Governor

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ANNOUNCEMENTS

Attention is directed to the fact that the Committee on Research Grants of the Illinois State Academy of Science has at its disposal a small sum of money to be disbursed in support of worthy research projects. Applications for grants will be accepted up to and including March 31, 1942. It is customary to give preference to scientists connected with the smaller institutions of the state.

Requests for grants should be accompanied by a brief statement of the training and experience of the applicant, the purpose of the investigation, and the estimated cost. Previous publications should be listed. At least two letters of recommendation should be transmitted directly by their authors. Correspondence may be addressed to William C. Rose, Chairman, Department of Chemistry, University of Illinois, Urbana, Illinois.

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1942 MEETING — URBANA — MAY 8-9

FUNGI AND MAN*

VERNE O. GRAHAM

A few years ago the speaker was deeply concerned over a number of ecological problems such as why more fungi occur during autumn than in the springtime, when an observer ventured the chance remark,—"Why spend so much time on these peculiar forms of life? Are they of any value to man?" Two answers to these questions may be proposed. The first is supported by all true scientists and includes the idea that all pure science is, across the centuries, of far greater value than the form which for personal reasons goes forth to find evidence in support of a proposition or conclusion arrived at from inadequate data. The second is based on our knowledge of the harm done by this great group of plants in causing decay of economic products. We know much more about their destruction than their control; we see the collapse of a structure weakened by the inroads of wood-inhabiting fungi; we are made aware of the constant expense incurred by replacement of decayed ties and timbers along our railroads; we note the dead and dying trees in our forests, and sometimes try to salvage some of the lumber before decay has completely destroyed its value. We look at fungi as food and hope that here we may find sufficient defense for their existence, and are dismayed to discover food value but little in excess of that found in cabbage. All these are superficial, and yield but little toward our understanding of this great group of plants and wherein they fit in the economy of life.

The greatest contribution of fungi to the balance of life is related to the decay of organic material. We need but imagine the effect of removal of all decay activities from our forests. Trees broken by wind or lightning crash to the earth year after year and lie until the forces of decay or fire change their nature from debris to soil. Unaffected by these forces the forest eventually would accomplish its own suffocation, mounting fallen timbers would heap higher and ever higher to mingle, first, with the lower branches, kill them by suffocation, and finally, bring death to the entire forest. Fungi increase in number with food supply, the debris of the forest furnishing food for countless numbers of them; with more debris more fungi appear; with decrease in this food supply occurs a corresponding decrease in fungi. In a complicated relationship these agencies continue to exist interdependent in their life needs. A dead branch lies on the ground but a short time before the scavengers of the plant world begin their work upon it. Sometimes the reduction process is accomplished by a single visible species, sometimes by many causing several forms of decay.

Each autumn, leaves carpet the earth, but in a few weeks all have disappeared except for a few kinds. Maple leaves color and make beautiful the autumn forest but on the ground they soon decay. Poplar leaves are more persistent as part of the forest carpet; not until spring has decay completely decomposed them. The dominant in any such carpet in this region is a mixture of leaves from some of the nine species of oak. The thick, leathery leaves and the presence of tannic acid make possible their persistence for more than a year. As rainfall slowly leaches preservatives from them, decay gradually softens the tough protective covering to produce a leafy substratum for the growth of many species of Marasmius, Collybia, and other small pileate fungi.

What are some of the environmental results of the carpet of leaves? The first important one accrues from the blanket-like covering of the soil tending to retain heat within the soil when the outside air is cold, and the prevention of warming processes from the outside during the time when the air is much warmer than the soil. Consequently the soil retains sufficient heat during the autumn months for the growth of terrestrial fungi long after the normal expectancy. During November it is not

*Address of the Retiring President before the general Academy membership met in convention at Evanston, Illinois, May 1-2-3, 1941.

unusual to find such species as Hygrophorus Russula and Tricholoma personatum among others pushing the leafy covering upward, tent-like, to gain position for spore dissemination. During this time humus is abundant and moisture has been retained sufficient for the wide spread development of mycelium. These conditions are ideally favorable for fructifications, providing the precipitation is at least average, and if no unusually long periods with freezing temperatures have occurred to penetrate the leafy-blanket and halt the development of the vegetative structure from which carpophores arise. With average autumnal conditions prevailing, the beneath-the-leaves habitat is populated by a flora unusually rich in species of fungi.

It is natural to question the application of the above facts especially when we account for the abundance of mycelial growth and fructifications for autumn only. Do not the same conditions have a vernal application? Do the results exactly correspond? The answer to the first question is yes, to the second, no. The leafy carpet retards the change of soil temperature both during autumn and in spring, but the retardation in one case while soil temperature is becoming warmer is disadvantageous and in the other when the change is from warm to cold is advantageous. In other words, the autumnal retardation of temperature change makes possible a continued production of fungi, while the vernal retardation delays the production. Consequently we find the first terrestrial fungi appearing at least a month after the vernal equinox, likewise abundant production continues for a month beyond the autumnal equinox.

Many people are disappointed by the absence of fungi during the months April until August, inclusive. The weather is warm and rainfall, especially during spring and early summer, is often sufficient for the growth of these elusive plants. Why are they not everywhere conspicuous, especially in the forests? A few reasons may be proposed, each explaining a different phenomenon.

From the paucity of terrestrial vernal fungi a few facts may be gleaned by direct observation. Fungi which are to be found are in pastures, open woods, and other habitats where sunshine may exert its warming influence. The genera Morchella, Peziza (see fig. 1), Coprinus, Panaeolus, Naucoria, and various field puffballs, although widely separated, make up the collections found during April and May. The warm sunshine has a drying effect in addition to its heat, consequently the arid months arrive almost simultaneously with the proper soil temperature within the forest. Add to these factors the time element required for vegetative growth of a fungus and the presence or absence of fungi during the various seasons becomes reasonable. Yes, but what is this time element? We have always supposed "mushroom growth" to be very rapid, requiring but a few hours, and that any time during the year when a high moisture content and warm temperature prevail, even for a very short time, mushrooms should be everywhere ready for collecting. The answer is: "mushroom growth" refers only to the production of carpophores and takes no account of the two weeks required, under most favorable conditions, for the mycelial growth necessary before our smaller fungi will appear in fruit, or the several weeks required for larger fungi. As evidence of the time element requirement, new data accumulates each year during August and September when, after several weeks of dry weather, rainfall again becomes normal or above normal, yet at least two weeks intervene before some of the smaller terrestrial forms appear, to be followed by medium sized and finally after several weeks by the very large ones. What interpretation may we consider applicable to such evidence? Certainly the accumulation of nutrition within the mycelial network and a widespread growth of the structure in order to contact and contain the supply of nutrition must occur before the dicaryophase condition and its stimulus brings forth rapid production of fructifications. The widespread growth and the large accumulation of nutrition required for larger species is relatively comparable to the extended time required for these plants to come to fruition. It is also true in general that large mycelial structures accompany and produce large fructifications, and comparatively small vegetative structures produce small carpophores. Hence, with the recurrence of rainfall regularly and abundantly following the deadening affect of several arid

weeks, events follow in normal sequence; one or two weeks of rainfall in which no fructifications appear, a week in which small fungi, such as species of Mycena, Collybia, Marasmius, and Coprinus are dominant, followed by succeeding days with new and larger forms gradually coming into and adding to the total number composing the fungal flora.

The continued growth of the vegetative structures of these saprophytes greatly reduces the leafy covering of the soil. Here again a balance is maintained between the amount of moist decaying leaves and the numerosity of fungi. The annual budget of fallen leaves is rapidly becoming an integral part of soil when the time arrives for the new autumnal carpet.

The normal human questions during spring invariably deal with why fungi are so few and far between. Recollections of the autumnal forest densely beset with hundreds of terrestrial fungi has led the usual observer to expect similar growth during the vernal season. The somewhat detailed discussion of ecological factors bearing on these questions serves to make reasonable the contrasting paucity and abundance.

Mosses, lichens and liverworts constitute a living substratum, nestled among and beneath the leaves to invite other entirely different types of fungal communities. Usually somewhat removed from the leafy floor and from the living mosses, liverworts and lichens, grasses grow, their roots and dead leaves giving sustenance for fairy rings of Marasmius oreades (see fig. 2) and Agaricus campestris on pastures and fairways.

An analysis of the interrelationship of the various parts of the substrata brings forth the tremendous importance of fungi. On a single stump, somewhat decayed, one may find six or seven species of fungi, each with its own peculiarities of action, but all functioning to eventually return the wood to the soil. In the growth of fungi chemicals are ecologically more important than for seed plants where physical factors are largely responsible for associational differences.

Diversity of saprophytism and parasitism is illustrated by the presence of Polyporus Schweinitzii always on pine, Mycena vulgaris on pine needles, Marasmius oreades attached to grass roots, Polyporus conchifer (see fig. 3) on elm twigs, Tricholoma transmutans on black oak roots, Polyporus tsugae on living hemlock and Nyctalis asterophora on another fungus, Russula nigricans.

The economic importance of fungi as related to the decay of structural timbers has by some been recognized for three-quarters of a century. In a letter of December 9, 1889, P. H. Dudley wrote to Charles H. Peck, state botanist of New York, calling attention to the loss due to decay of bridge timbers, ties, and the lumber used in building freight cars. He mentioned the prevalence of Lentinus lepideus on the ties of yellow pine (Pinus palustris Mill.) He stated that these were so numerous in main line tracks and so conspicuous during September 1889 as to be noticeable from the trains. "Pilei six to eight inches in diameter were frequent, while four in a cluster of small diameter springing from the same mycelium seemed to be a common mode of growth, this unusually wet season. The resinous matter in yellow pine in its natural state does not seem to check the growth of the fungus." This same fungus reaches ten inches across on the timbers used for construction at the parking area near Tower Falls in Yellowstone National Park. Construction here is mainly of Lodgepole Pine. Dudley further writes that Omphalia campanella Batsch (see fig. 4) was found fruiting on white cedar (Chamaecyparis sphaeroidea Spach) from May until October. White oak timbers frequently showed Fomes applanatus Fr. in fruit while Polyporus versicolor Fr. was very abundant. The absence of fungi in fruit upon ties of chestnut (Castanea) was as striking as its frequency on other woods. "It is a well known fact" he writes, "that chestnut ties last longer where the ground is damp, than where it is dry."

Concerning the presence of Omphalia campanella on the white cedar, one explanation seems sufficient. This fungus may have occupied the timbers for months, spreading vegetatively and causing decay without producing a single fruit; then with the stimulus of decay-chemicals in the substratum added to the presence of a moisture supply came to abundant fruition. The same, to a lesser degree, may be said of Fomes applanatus and Polyporus versicolor. They too are prolific in the growth of mycelium, and show but little tendency

to fruit until the supply of nutrition undergoes a marked chemical change, then, as though signaled by the code of race preservation, the pilei appear. The procedure varies in degree with different fungi, but the story is much the same. Some produce several successive crops for several years while the decaying wood becomes softer and softer in its reduction to soil.

Another interesting observation by Mr. Dudley concerns the abundance and destructiveness of Lenzites sepiaria Fr. Under the station platforms and the planking of the walks, he found its mycelium abundant, generally without fruiting, and follows with the observation: "This has not set men to thinking of better methods for replanking for they carry on the replanking exactly as of old, that is, in the best manner to promote the growth of a new crop of fungi. Consequently in a few years replacement is again necessary. Unseasoned timbers are especially susceptible and during a damp season will show traces of mycelium in two or three weeks. Well seasoned timbers contain inert mycelium if any at all and this remains inactive until moisture reaches it. This again starts decay. Some have suggested painting the timbers to protect them from the mycelium of decay but this proves of no value if moisture and the mycelium are present within, for in the same short period of time decay has weakened the wood and replacement must follow. Users of wood have long considered the fungi as merely accompanying the decay and not its cause, consequently they have done little to preserve the wood or to eliminate the fungi. So small are the spores and so readily disseminated that every crevice in the timber contains many which await the presence of moisture to begin the growth of mycelium and with it the decay of the wood." During a period of fifteen years the old railroad bridge over the north branch of the Chicago River in Harm's woods, west of Evanston, proved a most interesting illustration of these processes. The most prevalent of all was Lenzites sepiaria (see fig. 5) and ninety percent of the decay was attributable to this species alone. Remembering that these timbers were solid twenty years ago and that the trolley cars were then in use, one could with a minimum of time repeatedly visit these timbers and evaluate the destruction caused by the growth of mycelium within the wood.

The final paragraph of Mr. Dudley's letter is interesting: "As an illustration of simple and effective measures, I will give an example: When I was chief engineer of the Valley Railway of Ohio, I built some extensive trestles. This was in 1873. Before doing so I examined a number of trestles near Cleveland, Ohio, built of 10 by 12 or 12 by 12 timber, the life of which did not exceed seven or eight years. In examining them, I found that while the large timbers were sound upon the outside, internally they were all decayed. The small timbers, 6 by 8 used for braces and of the same kind of wood, were sound. The small size enabled them to season in the structure. This was an important fact, so I made all my timbers small, using more of them to give the proper factor of safety. One of these trestles is in use now, 16 years later. In this case, one of the three essential requisites for the growth of fungi was eliminated, namely, moisture in the interior."

Much of the discussion in the letter of Mr. Dudley refers to the decay of timbers but this may not apply to the decay internally of trees by parasitic fungi. Some fungi do perform the double function of saprophytism and parasitism exhibiting ability to thrive on a living or on a dead substratum. It is not unusual to find

PLATE I
Explanation of Plate

1a.—Morchella esculenta. The morel, sometimes called honeycomb mushroom occurs during spring.
1b.—Peziza coccinea (Scarlet Peziza) occurs during April. The inside of the cup is a brilliant scarlet color.
2.—Marasmius oreades. Fairy rings of this species and of Agaricus campestris are found on golf courses and pastures.
3.—Polyporus conchifer prefers to grow on dead and fallen elm branches.
4.—Omphalia campanella. Golden trumpets; with golden yellow caps; a multitude of these rapidly decay a log or stump. Caps ½ inch across.
5.—Lenzites sepiaria lower surface is gilled, but in some specimens is somewhat daedaloid: yellow and brown colors make the plant very attractive; on railroad ties.
6.—Fomes applanatus. Species of the genus Fomes are perennial adding a new layer of pores each year. Many of them are obligate parasites.
7.—Hydnum erinaceum. Hydnums are included among our edible fungi.
8.—Amanita phalloides (Deathcup). This is the most deadly of all to those who look for mushrooms for the table.

1a

1b

2

3

4

5

6

7

8

Polyporus Schweinitzii on the dead trunk of Pinus strobus or on the living trunks or roots of the same species, or to find Polyporus tsugae on either living or dead hemlocks. Because of such latitude of toleration, it is sometimes difficult to formulate laws for determination and prediction as is indicated by the following illustration: On the high point of land bounded by the two streams at the confluence of Turkey Run into Sugar Creek stands a hemlock afflicted for at least twenty years with Polyporus tsugae. The normal expectancy for such a disease includes mycelial growth within the tree until decay has changed greatly the chemical nature of the wood, the storehouse of food for the mycelium, then in the final stage of the life of the tree, the appearance of fructifications. This remarkable tree has all these years been host of a disease, and for at least eighteen years produced on its branches and trunk four or five pilei of Polyporus tsugae, yet the health of the tree has not greatly changed for several years. A few of its branches exhibit internal decay, but always such branches produce pilei of the disease-producing fungus. It is evident in this case that the disease is local in character, that the tree is parasitized in one sector only, the decay-producing mycelial strands follow the grain of the wood upward from its point of entrance, until the tissues of wood divide, some to a branch and some within the tree trunk. Strands then multiply within the branch until decay renders this member an unfit host. When such a condition arises fructifications appear, to scatter the spores on the winds to other hosts.

The destruction of trees in our forest preserves, especially in local areas, furnishes a splendid opportunity for observation and study. A survey of a single forest such as Harm's woods will reveal more than one hundred epixylous species. A few of these are obligate parasites, others fit into a varied classification. Some like Polyporus gilvus show preferment for dead trees and where present on living trees are attached to and deriving nourishment from dead wood. Others exemplified by Fomes connatus derive nourishment from the living wood of the tree trunk. Direct evidence of their presence is withheld from us until a considerable part of the tree is dead when fructifications appear. A third type may be said to live on either dead or living wood. Within this classification may be such as Fomes applanatus, (see fig. 6), usually found on stumps or logs in various stages of decay, but sometimes on the living trunk of Quercus alba. Such obligate parasites as Fomes connatus of maples, Fomes rimosus of Robinia pseudoacacia (black locust), Fomes Everhartii of Quercus, Fomes pinicola of conifers, Fomes pini of pines, Fomes juniperinus of Juniperus Virginiana (red cedar), Fomes fraxineus and Fomes fraxinophilus of Fraxinus (ash), sometimes surprise us by their presence after death has changed the living tissue of the host into decaying wood. These same parasites also sometimes surprise us by their presence on other than the usual host. Fomes pinicola, easily recognized by the presence of red color on younger tissues, is ordinarily expected on pine or other living conifers but sometimes occurs on beech logs. Fomes fraxineus, notoriously a parasite on ash, produces splendid fruits on cottonwood trees along the Des Plaines River near River Forest, west of Chicago. Fomes fulvus does not divide its host genus into species. It grows on any kind of cherry but is not adverse to the other half of the genus made up of wild plums. Fomes fomentarius is found on living deciduous trees but avoids conifers. Fomes ribes prefers bushes to trees, growing on Ribes (gooseberry) or Symphoriocarpus (relatives of the snowberry). On such very large bushes as witch hazel and alder may be found Fomes scutellatus. In Harm's woods where maple is abundant Fomes connatus is prevalent on that tree, and, were you to look no farther, your conclusion would be that this fungus is an obligate parasite. Somewhat rarely in other localities this disease also affects elm and beech. In the forest preserves of Cook County living elms are exceptionally free from parasitism by fungi, but on the dead twigs will almost invariably be found the attractive cup and saucer shaped fructifications of Polyporus conchifer. Had Mr. Dudley who spoke of the absence of fungi on wet chestnut timbers known of later findings, he would have been much surprised to learn that more than 150 different, easily observed fungi could be found on the dead and dying remnant of

that tree. That these are not minute species hidden from the average observer is indicated by the facts that—

29 are of the genus Polyporus

24 are Agarics (gilled mushrooms)

19 are Porias

18 are of the genus Stereum

9 are of the genus Fomes

The remainder are largely resupinate forms of the family Thelephoraceae.

Another contrast with the statements of Mr. Dudley are the observations about the reconstructed village, Lincoln's Salem, Illinois. The timbers used in this village are infiltrated under high pressure with zinc chloride. The effect of this salt on the protoplasmic content of the mycelium is immediate and powerful, causing plasmolysis and sudden death. It seems probable that timbers so treated may endure for several centuries.

In more recent time, an ever increasing use of preservatives adds years to the endurance of structural timbers. The conditions prevalent a century past, when lumber and labor were cheap, occur less frequently in modern times for the best economy encourages building for the years.

We cannot but wonder concerning the details of adjustment for the balance of life. What biotic changes occur within the host and how are these adjustments accomplished? The softer plants which furnish food for man have been carefully observed and studied in order that strains resistant to disease may be selected. Nature carries forward a selective process producing on the one hand a host sufficiently resistant for endurance of the numerous parasites, and on the other hand, parasites strong, but not too strong, in order that their life and their food supply may continue. A parasite attaining its ecological factors in one part of the world, suddenly released in another region may destroy its host before resistance adaptations occur. A single parasite nearly eliminated the American chestnut from our forests. Such life processes can in the medical field be many times exemplified by such examples as susceptibility to tuberculosis, of people who come from south of our border. The parasitic germs in this case find a virgin field for development where growth may be rapid and without host resistance. Application of these principles to our forests helps to establish understandings of why trees may in various stages of decay live on for many years, finally to be killed by secondary parasites which find entrance through wounds made by the original fungal growth.

Speaking of fungi and man invariably causes many people to see but one side of the subject and they properly ask, "How can we know without learning to recognize all the fungi which ones are edible?" Without knowing them as individuals your diet must be considerably restricted. Analysis of the fungal flora of Illinois and the region within one hundred and fifty miles of Chicago shows the following rules applicable. Our most poisonous mushrooms are gilled. All fungi are non-poisonous which grow on wood, except the beautiful Clitocybe illudens, which is a large, bright pumpkin-yellow gilled-mushroom. Among other edible fungi are all puffballs if used before the changes for spore production, that is while white throughout the cross section, all coral mushrooms (Clavaria and Tremellodendron), morels and pezizas, and finally the black fungi of the genus Xylaria, as well as the peculiar ones which appear shaggy with white hair-like aculei, belonging to Hydnaceae (see fig. 7). The very poisonous mushrooms grow on the ground and belong to the genus Amanita (see fig. 8). Other mildly poisonous mushrooms of other genera of the Agaricaceae are terrestrial.

In conclusion, I wish to express the hope that some of these scattered ideas may make future visits of yours to forests, fields and mossy bogs more interesting, and that you will try to recognize some of the numerous plants which you formerly passed by with the remark: "Just another toadstool". It is much more than a toadstool and its very presence in a particular place must arouse a whole chain of ideas. Your conclusions may then arouse other new associations out of which may grow *your* ecology. Fungi whether epixylous or terrestrial fit closely into the scheme of human existence and each has an important place to fill in the total organization of relationships between fungi and man.

MICHAEL S. BEBB, ILLINOIS BOTANIST AND LETTER-WRITER*

EVELYN I. FERNALD

Rockford College, Rockford, Ill.

The letters of Michael Schuck Bebb (1833-1895) are of interest not only to the botanists but to the historians of Illinois. In them are recorded the observations of a man with a keen critical mind and with accurate power of observation combined with a deep love for his fellow men and the world about him. Scraps of wit and humor scattered throughout make them easy to read.

Early in life, in 1861, he corresponded and exchanged plants with the Rev. Joseph Blake, a Maine botanist. In one letter, he gives the following description of himself:

"I herewith hand you my photograph—and here just for a dash at something that may help you to guess what manner of man I am—Hoefland says if a man knows not at thirty his purpose in life it is probably because he has none—Alas Poor Yorick, I have but six months left wherein to find my purpose—and 'still it is a fleeting.' But I must not spin out so—western man—born and bred—Massachusetts wife—two children—mix-up (strange as the mixture is) farmer-naturalist-musician—like *tough* reading—radical republican (turned insurrectionist) never made a noise in the world—never tried—don't think I should have succeeded if I had—Father a lawyer and politician—here is the end of my sheet, so I must stop."

In another letter to Blake written December 9, 1864 from Washington, he writes in a more serious vein, as follows:

"I will never be much of a botanist but I can enjoy the dear flowers—and the fellowship of true plant-lovers as keenly as the biggest Dr. Hooker of them all—and I question if even he found more satisfaction in working up *Welwitchia* than have I over my microscope and seeds of *Juncus*—After all perhaps we lose in sentiment and enthusiasm to gain in knowledge and fame without enhancing our enjoyment. It is not best to be such a topping Scientist as to lose one's interest in the common things of the nearest meadow—I mean of course for humble botanists who seek recreation—and the cultivation of mind and heart—rather than to study and scramble to augment their reputations as Naturalists."

He corresponded with practically all of the prominent botanists of his time and in the library of the Gray Herbarium at Cambridge, Massachusetts, letters to Bebb from eighty-seven contemporaries are deposited. Copies of thirty-two of his letters to the Rev. Joseph Blake were obtained from the University of Maine through the courtesy of Professor F. H. Steinmetz after they had been brought to the author's attention by the generous interest of Professor Neil E. Stevens of the University of Illinois and copies of over two hundred letters to Walter Deane and others from the Gray Herbarium of Harvard University through the courtesy of Professor M. L. Fernald.

By reading these letters you can understand how he was able to accomplish so much work of real value at considerable distance from any other botanists. In the following letter to Walter Deane (February 8, 1888 from Rockford, Illinois), he gives us an explanation of his "technique".

"My tailor has always made two pockets on the hips of my pantaloons. I am too old perhaps to acquire new habits making them useful. I carry no revolver and have a time honored place for my handkerchief. But I have just learned what to do with them and I find they are mighty convenient. I pity people that don't know how to use hip pockets. In one I keep a whole bunch of blank tickets. No matter what I am doing, if it pops into my mind to ask some friend a thousand miles off a question, I out with a ticket, make a memorandum of the question and slip it in the other pocket. So now when I sit down to write to you I go over the accumulation and find two which read as follows 'Deane ask to refer to *Salix Cutleri* Tuck Sillim

*Address presented by the then-retiring president of the Academy before the membership at its annual meeting held in Galesburg, Illinois, May 2-3-4, 1940.

Journal 45; 36 what reasons there given for discarding the old name *S. Uva Ursi* Pursh—please copy anything likely to be useful'."

While in Washington during the Civil War, he became acquainted with William M. Canby and some of the pleasure and stimulus he obtained from that relationship is passed on to Blake, December 9, 1863:

"Yes, Mr. Canby has been very successful—I presume he has told you about our trip to New Jersey—and the East shore of Maryland—We got a fine lot of plants—and thanks to many favoring circumstances made satisfactory specimens. To what new plant do you allude —The *Rynchospora* heretofore confounded with *R. alba*?—Your remarks about finding new species are very just—but I try to keep my mind as free from this whole matter as possible—Envious strife and ambition to possess large herbaria—or to add a species or so to the 100,000 already known tends to embitter the life of a naturalist—and to smother the higher enjoyments he might otherwise derive from his studies—Darwin's observations on the dimorphism in *Linum* are worth a whole batch of new species."

In another letter of February 18,. 1863 he mentions another significant contact.

"Dr. Torrey is here lecturing at the Smithsonian on 'Flame' gas light &c.—I was talking with him about our *Oaks* and was glad to hear him say that all the Chestnut group must be put back as Micheaux left it—Certainly no *Western* botanist with a clear idea of species would separate *Q. castanea* and *Q. montana*—for I have often gathered *both* from the same tree—the former at the top and the latter from the lower branches!"

His time in Washington was not spent entirely in a botanical way, as is indicated in this account sent to Blake, July 16, 1864:

"The capitol is safe. The 'Pension Office Guards' were regularly mustered into the service of the U. S. for thirty days. The Rebs got wind of the movement and retreated precipitately! Perhaps the advance of the 6th Army Corps may have contributed to the discomfiture of the enemy, but still the Moral effect (?) of 60 valiant quill drivers ordered to Fort Baker to do garrison duty must have been stunning! Well! now that the emergency is past and I have retired from active military life—the mails reopened etc. I have taken to the pen—answered all the letters I had lately received, and getting in the way of it I believe I will keep on and stir up some of my delinquent correspondents beginning with your esteemed self."

A very fine account of Bebb was written by Walter Deane of Milton Academy, Milton, Massachusetts, and published in 1896 in the *Botanical Gazette*. (This also includes a complete list of his publications.) They exchanged letters and specimens and were very close friends. It is singular that they never saw each other. They had arranged to meet each other at the Columbian Exposition in Chicago but missed each other by a few days—a great sorrow to both of them.

When the father of Michael, William Bebb, former governor of Illinois, purchased five thousand acres of land in Winnebago County and in 1850 most of the family and belongings were sent via the Miami canal to Sandusky and thence by the Great Lakes to Chicago and overland to Fountaindale near Seward in Winnebago County, Michael and a brother drove a herd of cattle the four hundred miles. A glimpse of that trip is thus pictured for us:

"How beautiful the rolling prairies were before man's incoming! You never saw an old fashioned prairie "breaking plow"—It was drawn by ten huge oxen and cut a furrow 30 inches across—The soil was cut only about two inches thick and was laid over as smooth and even as the boards of a floor. On the 'land side' stood in all the purity and freshness of its pasture beauty the native vegetation—on the other was a black field with not a vestige of living plant to be seen—such an outfit—and there were thousands of them at work all over the country—would destroy in one hour more beautiful plants than have been collected by all the botanists of the state since the Indians were driven out—A few choice things were left on stony knolls where the stones would dull the *sharp* edge of the breaking plow—or in nooks too irregular in shape to pay for cultivation but even they gave way a few years later to blue grass and cow pasturage—*Troximon* which grew out in the open and upon the richest and sunniest slopes was about the first choice

thing—botanically considered—to be utterly exterminated. I have not seen a plant of it growing in years."

Fig. 1 (above). Michael Schuck Bebb as a boy, copied from an old daguerrotype loaned by A. S. Ruhl of Rockford, Illinois.

Fig. 2 (below). Fountaindale, Illinois, home of M. S. Bebb.

An old daguerrotype given to Mr. Antes Ruhl of Rockford, Illinois, by members of the Bebb family, represents Bebb as he looked at that time (Fig. 1), and a later photograph (Fig. 2) when he was in the prime of early manhood.

On the county line road northwest of Rockford and northwest of Byron, the father built a new home, designed by Downing. How spacious the house and grounds were for those early pioneer days is shown in Figures 3 and 4.

Bebb's interest in plants began when he was very young and persisted throughout his life. When Emerson's *Trees and Shrubs of Massachusetts* was added to the family library in Ohio, it was his first real contact with formal botanical science. At this time, he began to collect plants, and the splendid herbarium of 50,000 sheets now in the Field Museum was built from such a simple foundation. Since he did so much of the work in those days without instruction of trained and experienced botanists, the records on many of the earlier sheets are incomplete. However, by the time (1873) he became interested in *Salix*, he had had sufficient opportunity to know more of the established practices in systematic botany.

From 1857 to 1861 he lived in Odin and Salem and the vicinity of Springfield and at these places made extensive collections. From this locality he went to Washington, D.C., where he remained until 1867. At that time he purchased the old homestead at Fountaindale and made his home there or in Rockford until his death in December 1895.

His studies of the difficult genus *Salix* are more valuable because he made observations of living specimens as well as pressed specimens. In a Salicetum located near a stream at Fountaindale, he planted willows from all over the world. Dr. Hooker sent 1100 cuttings of 175 species from the willows cultivated at Kew and they all lived. When Charles Sprague Sargent was planting willows at the Arnold Arboretum, Bebb sent cuttings and detailed directions for their arrangement and culture. The following is an extract from a letter to Walter Deane written on February 5, 1892:

"I have been fussing over Willows, my usual winter occupation, and have really become quite enthusiastic. It began with work done in a perfunctory way to discharge obligations to others, but in the prosecution of this, certain fresh lines of investigation had to be followed up

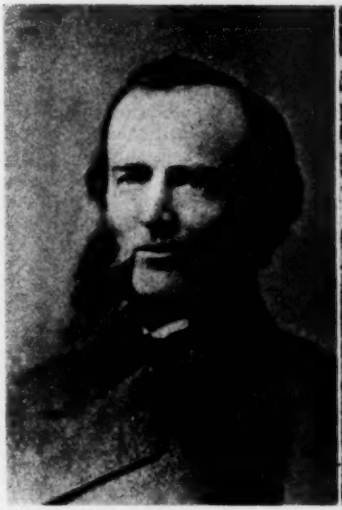

Fig. 3. Michael Schuck Bebb, from a picture loaned by A. S. Ruhl of Rockford, Illinois.

Fig. 4. Fountaindale, Illinois. Home grounds of M. S. Bebb.

and these in the end led to a better understanding of some old questions laid aside as unanswerable. Finding my way Clear I was in fine mood to go on and block out three or four batches of Willow notes for the Gazette. It is only in this way, now, that I can keep up the pleasant illusion that I still belong to the fraternity of working botanists. I envy you your industry and vim, but after all this is only relative. Young Macoun writes that 'his hours are from 8 A. M. till midnight with an hour off for luncheon and dinner' (presumably half an hour for each.) I wrote him that he might work that way in Germany but he had better stop right off or he would get a rap on the head to remind him that the thing couldn't be done in this climate."

Bebb became the world authority on *Salix*. In his early days he devoted some time to *Carex* and corresponded with "that young man Bailey" (Liberty Hyde Bailey).

Among his most important contributions to science are the publication of the Willows of the Peary Auxiliary Expedition in *Bulletin V* of the *Geographical Club of Philadelphia*, of notes and articles in the *Botanical Gazette* and *Garden and Forest*. He selected material from which Mr. Charles E. Faxon drew the willow plates in Sargent's *Silva of North America* and later criticized the sketches. His death in 1895 prevented the completion of the revision of the willows for the *Flora of North America*.

In his lifetime the appearance of northern Illinois underwent many changes and botanizing became more difficult. On January 28, 1891, he wrote to Walter Deane:

"The electric car lines have been extended in several directions one or two miles beyond the city limits (mainly to boom suburban lots) and will afford me facilities in reaching some very desirable botanizing grounds which last summer were beyond my walking ability. One is the hills above the city on the bank of Rock River which last summer I could only visit twice. Now I can go to within a mile by the cars. The other is one upon which I am counting greatly, viz., the right-of-way of the Chicago & Northwestern R. W. which was fenced in thirty years ago and has of course never been cultivated or pastured since.

"All I have the dread is that Bluegrass will have spread in from the farms alongside and smothered out most of the indigenous vegetation."

On May 22, 1894 he wrote to Walter Deane:

"The boys wanted me to join them in an excursion to a favorite collecting ground of theirs on the lake shore near Whitings, Indiana. I was quite as eager as the rest so one morning we took an early train and did not get back to the city till after dark. We had a walk of a mile and a half along the lake shore, after leaving the R.R. station and then turned off into what was expected to be a region of alternate sand dunes and bogs—heavily wooded in some places,—open and sunny in others—aquatics in the water and the plants of hot sand banks a few rods away. Trees for shade —underbrush for seclusion—where we could cook and eat our dinner with a feeling that we were far removed from man's intermeddling—To the very great disgust of my entertainers we discovered that the whole district for miles had been taken hold of by a land improvement company. The bogs had all been drained by deep ditches—discharging into the lake—the trees cut down or pulled up by the roots with some powerful machine—and the whole surface *burned over*."

His whole family was actively interested in his botanical work. An intensive study of the plants of Cook County, Illinois was made by his son Robert, and his son William was a well known naturalist in Illinois and Indiana.

In this study of the life of Michael Schuck Bebb we realize more clearly than ever that in the youthful scientists and in the amateur scientists there is much of immeasurable value which should be conserved.

HORMONE CONTROL OF REPRODUCTION AND SECONDARY SEXUAL CHARACTERS IN FISHES

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AN ABSTRACT

There is great diversity in the reproduction, reproductive habits and in the secondary sexual character of fishes. The various peculiarities in structure and function furnish a rich background for a study of endocrine factors controlling reproduction and the sex accessories.

Sex and sex reversal. Functional protandric hermaphroditism occurs in some fishes (*Sparus*) and many groups furnish instances of non-functional hermaphroditism. In *Xiphophorus helleri* it is reported that males develop from young females by sex reversal. In other cases experiments involving removal of ovaries have sometimes resulted in regeneration of a testis. It is indicated that in some fishes sex is indeterminate, lightly held and easily reversible. It is not surprising, therefore, that gonads are easily modified. Testosterone propionate administered in appropriate doses has caused degeneration of the ovary in *Phoxinus* and several poeciliid fishes and estrogenic hormones have produced a breakdown of the testis or the formation of an ovotestis.

Relation of pituitary hormones to germ cell stimulation and to ovulation. Precocious maturity has been produced in young fishes by implanting the pituitaries of mature fishes in the eye and in other locations. A similar effect has been obtained by grinding pituitaries and injecting them into the peritoneal cavity. Gonadotropic hormones from mammalian sources have also been found to be effective in producing early maturity in fishes. In general, a low degree of group specificity is indicated in the gonadotropic response.

Ovulation occurs in numerous species of fishes when pituitary extracts, ground pituitaries or whole glands are injected or placed in the peritoneal cavities of fishes of the same species. The pituitary hormone of one species is often found to be effective in other species of the same general group but ineffective when administered to a species of a widely separated group. For example, the pituitaries of teleost fishes have been found to be ineffective in cyclostomes.

Hypophysectomy when performed upon a fish undergoing ovulation inhibits completion of the process but ovulation is resumed when pituitary substance is injected into the hypophysectomised fish.

Secondary sex characters. It is convenient to divide secondary sex characters of fishes into two groups. The first includes temporary characters or structures which appear normally only during the breeding season. Pearl organs, nuptial coloration, the mucous glands of the kidneys of the Stickleback and the elongated ovipositor of the Bitterling belong to this group. The second group consists of permanent organs developed at the onset of sexual maturity and include the gonopodia of various fishes in which internal fertilization occurs.

The appearance of temporary secondary sexual characters is inhibited by castration and it is assumed that the characters are controlled at least in part by hormones secreted by the gonads. A better demonstration of the control of secondary sexual characters by estrogenis and androgenic hormones has been furnished by experimentation on the gonopodium of poeciliid fishes. It has been shown that castration inhibits gonopodial development but development is resumed if there is testicular regeneration. A piece of regenerated testis about one fiftieth the size of a normal mature testis furnishes sufficient hormone for the complete development of the gonopodium. Smaller amounts of testicular tissue furnish hormone enough only for the earlier stages of development. When

completely castrated males are treated with an androgenic hormone (ethinyl testosterone) gonopodial development is resumed. When females are treated with ethinyl testosterone the anal fin undergoes a metamorphosis and produces a gonopodium which is atypical but contains the specific characters of the male gonopodium. It has been found that a very dilute solution of the hormone, I mg of the hormone to 110000 cc of water, will produce the earliest stages of metamorphosis but that increasingly greater concentrations are required for the development of each succeeding stage. Reaction to the hormone takes place more rapidly in younger specimens and at higher temperatures. When development has ceased because the temperature level is too low or the concentration of hormone is below that which is required further development may be induced either by raising the temperature or by increasing the concentration of the hormone. It is inferred that in the normal development of the male gonopodium very small quantities of hormone are required to initiate development but that increasing amounts are required for each succeeding stage.

PATTERNS OF NEGRO MUSIC

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The study of musical forms can make an important contribution to an understanding of the nature of human civilization, its processes of change, and the historical relationships between various bodies of custom. That the value of this contribution has been thus far but little recognized either by students of human civilization or by musicologists is not strange, since each field is sufficiently broad to demand the entire attention of specialists. The student of comparative culture must be prepared to deal with the habits of peoples whose modes of behavior differ as widely as do those of Eskimos and South Sea Islanders, of Zulus and aboriginal Australians. The musicologist, also, even though he may restrict his research to problems in the field of western European and American music, must utilize techniques so specialized that little time remains to him for the consideration of materials outside his specialty.

We may thus ask at the outset how the comparative study of music can contribute to an understanding of the processes of human civilization; or, conversely, how a knowledge of these processes helps the investigator concerned with understanding the derivation and significance of a particular musical style.

To answer the first question, it must be recognized that music, as a part of any given body of tradition, can be studied like any other aspect of custom. But the peculiar value of studying music for this purpose is that, even more than other aspects of culture, its patterns tend to lodge on the unconscious level. Especially as regards the processes of change, it seems to manifest that phenomenon which, in the field of linguists has been termed "drift." This implies an almost imperceptible, but consistent and steady change as a result of the continuous introduction of many small elements, all of which are in accord with the underlying structure of the accepted musical style. The cumulative result is that this process eventuates in something which, though differing from the earlier form, is still recognizably related to it.

This process is to be seen, for instance, in the changes that, over the generations, have taken place in style of European folk music and, in more recent times, in that of our more sophisticated musical forms. Each generation, we find, has had its "modern" music, to be protested against by those devoted to an earlier convention. Yet each new step toward "modernism" has been shown to consist of nothing more than the utilization of intervals which represent the next series of overtones to the combinations already accepted. The point is that this process has gone on within the framework of our polyphonic patterns of music which emphasize harmony, patterns that were established when unison singing gave way to two-part melodies, and later, in the Middle Ages, much against the edicts of the Church, the major triad was completed by the addition of a third element.

For the musicologist, an understanding of the wider significance of changes of this sort in our own culture, and the variations in tonal and rhythmic patterns that exist outside our own civilization, afford a perspective that is not only useful to any investigator of human behavior, but in this particular field materially broadens the basis of his approach to his specific concerns. The very techniques that are employed in analyzing foreign musical idioms are, from this point of view, revealing. It was not until a generation ago that the musical significance was realized of the fact that in our society, music is more intimately related to the playing of instruments of fixed pitch than in any other. Today the importance of the piano, with its rigid tonal system, in conditioning our musical reactions is recognized as paramount, not only in

shaping the way in which we express ourselves musically, but the way in which we hear music. It is recognized, of course, that the particular scale we employ is a convention arbitrarily selected from subtly differing tonal values that have an infinite range; that, for example, whole tone scales, or pentatonic scales can give material quite as adequate for the making of musical style as the chromatic system prevailing in our music. Yet the fact that within the limits set by our scale system we regard true pitch as so important, sets us off from folk who do not base their music on mechanically tuned instruments; among such people, for example, a reaction of distaste such as the trained musician in our culture feels when a singer

Fig. 1. Drummers and dancers in the market-place of Kano, Nigeria (British West Africa).

Fig. 2. Members of a cooperative society singing to give rhythm to the hoe-strokes of those working. Dahomey, French West Africa.

flats a note is, for example, unknown. A given tone has only a more or less constant value, and even a quarter-tone deviation causes no discomfort, if, indeed, it does not go unrecognized.

The comparative musicologist, however, will realize that with casual regard for true pitch may go a far greater sensitiveness to rhythm than is the case among ourselves, where in all but the most sophisticated "modern" compositions, and in certain forms of dance music, rhythm is subsidiary, and rarely falls outside the limits of the 4/4 or 3/4 patterns, or some variant on these. The difficulties which many persons in our culture experience in beating out a 5/4 measure is an example of this. For such persons, to master a simple South African piece on the marimba which requires the player to follow a 4/4 beat in the left hand, and a 9/4 in the right—with a rhythmic consonance every 36 beats, is well-nigh impossible.

For the musician, then, to understand that the idiom of his own culture is merely one of an almost infinite variety is of considerable value; a further understanding of the significance of this fact in terms of the techniques employed in recording and analyzing foreign idioms is equally important. As in all scholarly research, to attain the greatest precision and accuracy is essential, and in the study of a strange music, this can be achieved only by the use of recording apparatus. Because of early conditionings, the ear of a person in any culture is so trained that one who attempts to study differing styles soon learns that he cannot trust himself to write down the music he hears, however facile he may be. Having collected his data on cylinders or disks, he can, however, later in his laboratory, with the aid of tuning fork and metronome, transcribe what has been brought from the field. Here, without distraction, he can analyze prevalent scale systems, record the complexities of rhythm, indicate the extent of individual variation in singing and, should he have sound films to work with, attempt to assess such intangibles as singing style and motor behavior while singing.

No body of music can better document the advantage to be gained, both by the social scientist and the musicologist, from research in the field of comparative musicology, than that of the Negro peoples of Africa and the New World.

For here are to be found patterns which, because of the historical relationships involved, have certain broad similarities that reflect the contacts between peoples of Africa and the Negro New World, and at the same time reflect the local developments that have occurred in the various areas involved. Negro Africa, south of the Sahara, comprehends thousands of tribes, among all of whom music plays an important rôle in the daily life and the ceremonial round. The Negro slaves who were brought to the New World, deriving principally from West Africa and the Congo, brought their music with them, not only to the United States, but to the Caribbean Islands, Central America and the northern tier of South American countries, the Guianas, and Brazil. And in all these areas Negro music to some extent reflects this African background. In essence, this forms the fundamental basis for the overlay of European characteristics which, differing in terms of the contacts of these people with Spanish or Brazilian or French or Dutch or English musical styles, and the intensity of these contacts, gives to the musical expression of each local group its special flavor.

The principal characteristics which mark off the underlying pattern of Negro music may be broadly described. The convention whereby the statement of a theme by a leader is repeated by a chorus, or a choral phrase is balanced as a refrain against a longer melodic line sung by the soloist, is universal. This has been commented on by all who have heard Negroes sing in Africa or elsewhere, and is to be found in spirituals and work songs in the United States as well as in various kinds of melodies heard in the West Indies and South America. An intimate and often intricate relationship between the melody and its accompanying rhythm—carried on by drums, rattles, sticks beaten one against the other, hand-clapping or short non-musical cries—is also ubiquitous. So prominent is the element of rhythm in Negro music that this music is ordinarily conceived as relegating its melodic line to second place, though this concept has only partial validity. For as is demonstrated by the songs sung by choruses of chiefs' wives in Dahomey, West Africa, on the occasion of rites for the royal ancestral cult, or by some of the Shango cult songs from Trinidad, British West Indies, or by some of the Brazilian Negro melodies, a long and complex melodic line is by no means unknown in Negro songs. Yet the need to ornament an underlying rhythmic structure is fundamental, and when Negro music as a whole is considered, this trait must receive close attention.

The phonograph records played in connection with this discussion in illustrating the characteristics of Negro mentioned above, and documenting the unity of Negro musical style, bear out the theoretical and methodological points with which this discussion opened. It is evident, when these melodies and rhythms from South Africa, from the Congo and West Africa, from Brazil, Trinidad, and Haiti, are heard, that the derivation of the music sung and played by the Negroes of this country will become apparent. At the same time, when the differences between the musical style of these various areas are noted, it will be remarked how these various musical conventions, regarded as cultural patternings, throw light on what has happened to aboriginal Negro musical endowment in contact with various European cultures. The Brazilian songs, it will be noticed, show a strong Iberian overlay, through which African stylistic values manifest themselves in terms of the complex rhythms of the percussion instruments, and in the prevalence of the leader-and-chorus convention. It will be noticed in the Trinidad recording of "Jesus, Lover of My Soul" how, using a "Sankey"—a Sankey and Moody hymn—the thematic material has been so reworked in terms of African conventions that they finally take a form far removed from the slow stately measures of the original—a form, indeed, that is essentially the form of the "swing" rhythms that United States Negroes have introduced into the secular dance melodies popular today among all groups in this country.

These records are the following; unfortunately, here only tribe or area represented, type of song, title, and in the case of commercial discs, the company manufacturing the record, and its number, can be given:

Africa

South Africa

1.	Zulu: Nkonto Ka Tshaka	Gallo (Pty.) Ltd., Johannesburg, South Africa, No. G. E. 86
2.	Zulu: Malombo	

Congo

3.	Bahutu: Chant and Dance	Denis-Roosevelt Expedition, No. 10. Reeves Studios, Inc., New York City
4.	Babira: Songs	Same, No. 2
5.	Manbetu: Songs	Same, No. 1
6.	Congo Dialect Song: Iduba	British Zonophone Co., London. No. E. Z. 439

West Africa

7.	Yoruba: Igi Da Pa Ele Po	Zonophone No. E. Z. 305
8.	Yoruba: Oyibo Sewun Ti Oto	Zonophone No. E. Z. 549
9.	Yoruba: Tani Nawa Oni Baba	Zonophone No. E. Z. 426
10.	Fanti: Kwesi Kadagyi	Zonophone No. E. Z. 560
11.	Fanti: Nsamo Pom	Zonophone No. E. Z. 475

New World

Brazil

12.	Macumba: No Fundo Do Mar	Victor (Brazil) No. 34158
13	Macumba: Caboclo do Matto	
14.	Batuque: Babão Miloquê	Victor (Brazil) No. 33253-A
15.	Jongo: São Benedicto é Oro Só	Victor (Brazil) No. 33380-A

Haiti

16.	Vodun song: Ibo Lélé	General Records, New York, No. 5001
17.	Vodun song: Joué Kanga Joué	
18.	Vodun song: Moundongue yè yè	General Records, No. 5002 B
19.	Vodun song: Ciyè Ciyè 'ti Bobine Carrè	General Records, No. 5003 B

Trinidad

(Note: All Trinidad recordings were made in the field by M. J. Herskovits, during the Northwestern University Expedition of 1939.)

20.	Bele song: Me no well-o	No. 65 b
21.	Bele song: Chamber po', Chamber po' Lady	No. 31 a
22.	Bongo song: Killin' Peter Agent	No. 70 a
23.	Bongo song: Dolaido	No. 79 a
24.	Bongo song: I wan' a Pretty Woman	No. 47 b
25.	Spiritual: Our Father	No. 31
26.	Spiritual: 'Rasslin' Jacob	
27.	Baptist Shout: Jesus, Lover of My Soul	No. 58 b
28.	Shango cult song: Yemanja	No. 96 b
29.	Shango cult song for Osho: Menia, Menia	No. 97 a
30.	Shango cult song: Adjadja-e	No. 98 a

This music has considerable point for the current controversy as to the derivations of American Negro songs, particularly the spirituals. The discussion of this matter goes back to about thirty years ago, when H. E. Krebhiel published his volume "Afro-American Folk Songs," in which he attempted to show that the spirituals were essentially African. His hypothesis was generally accepted, until a re-examination by various students some ten or fifteen years ago noted striking similarities between the spirituals, and hymns—in some cases what may be called folk hymns—of the white people of this country, in both melodies and words. Since then, scholars have tended to align themselves on one side or the other, though, curiously enough, in no case has anyone who has written on the matter had any large acquaintance with African music, even, indeed, as large an acquaintance as would be gained by hearing the series of records played in connection with the presentation of this paper.

To a person acquainted with the range of local style included in such a collection as is represented in the records listed above, this discussion must seem pointless, and somewhat unrealistic. For one thing, the problem of origins goes beyond the spirituals, involving also the roots from which such other forms of Negro music as work-songs, songs of recrimination, "blues" and other dance forms have been derived. As far as the spirituals are concerned, a realistic approach would seem to indicate a conclusion that their present form represents responses on the part of Negroes both to the music of the Whites heard by them in this country, and a reworking of this material in terms of the aboriginal stylistic patterns of their ancestral African forms. In stating this, the renderings of the spirituals written for concert presentation are not meant, for though they may be beautiful, they are nonetheless artificial versions, translated into current majority patterns of music. The living spirituals, sung by devotees affiliated with groups whose worship is outside the commonly accepted conventions of American religious behavior, sung in lowly Negro churches, in places of worship such as are colloquially known as store-front churches, and the like, are quite different. For in these humbler gatherings, the "swing" element, so important in secular Negro song, also predominates in the sacred songs, and the synthesis of both African and European elements is plainly to be discerned. Jazz and swing are rarely taken into account in discussions of the derivations of Negro music. Yet it is not an accident that the exponents of these musical styles who are most effective in their presentations are Negroes. The importance of rhythm in this dance music, the improvisation that characterizes its playing, the repetition of thematic material are all distinctly African. It is more than chance that this music is so closely associated with the dance, for the relationship of song and rhythm to dance in Africa and Negro America is fundamental.

In considering some of the problems present in the study of Negro music, therefore, it has been indicated how advantageously certain controversial issues can be approached through the use of these materials. In the case of a question which is of great importance for this country at the present time, that of the derivations of Negro custom in general and the carry-over of Africanisms in all aspects of Negro behavior, it has been shown how an approach of this kind affords definite data that throw light on the mechanisms which can then be considered in terms of their applicability to the change in other aspects of custom resulting from the contact of Whites and Negroes. From the larger point of view, also, it is to be seen how the study of comparative musicology makes for an understanding of the fact that the musical style of our own culture is but one of an infinite number of possible varieties of musical expression, and that the student who approaches our music with this fact in mind will find new values in it which arise from a deeper realization of its significance as a part of the musical resources of humanity as a whole. Finally, as concerns the student of society, it is apparent that music, objectively recorded and competently analyzed, can offer effective guides to an understanding of the mechanisms of cultural change, and of the historic relationship between cultures as they exist over the earth at the present day.

A SUMMARY OF OUR KNOWLEDGE OF ENDOCRINE MECHANISMS IN CRUSTACEANS*

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Definite demonstration of the presence of an endocrine mechanism in invertebrates is of quite recent origin, extending back not more than about fifteen years. Biologists have, nevertheless, suspected for several decades that such mechanisms existed among these lower animals. When one considered the fact that almost every basic physiological mechanism found in the Vertebrata appeared to have its counterpart somewhere among the Invertebrata it was not unreasonable to presume that hormonal coordinatory mechanisms were operative there just as in the Vertebrata. Many problems in invertebrate physiology which remained quite refractory to solution solely in terms of nervous coordination recently have yielded much ground in terms of endocrine coordination. A number of general reviews of the subject have been prepared, namely Koller, 1929, Hanström, 1937a, von der Wense, 1937, Koller, 1938, Lelu, 1938, Hanström, 1939, and others are in preparation.

The first invertebrate group to provide unequivocal evidence for the possession of an endocrine mechanism was the Crustacea (Perkins, 1928). And today we probably have as large a body of information concerning crustacean endocrine physiology as we have for any other invertebrate group, with the possible exception of the Insecta. Even in these best known groups, however, our knowledge is still very rudimentary and sketchy. One who is primarily familiar with the relatively refined and detailed state of the field of mammalian endocrinology must look with patience and understanding upon this new field which is only now concerned with the rough determination of hormonally controlled processes, and the sources of the hormones involved. Furthermore, the investigation of invertebrate endocrinology is rendered somewhat difficult by the small size of most of the animals which must be investigated and also due to the general phylogenetic tendency toward decrease in structural differentiation and segregation of organs or parts of organs concerned with specific functions. This last tendency, of couse, culminates in the Protozoa whose total structural bases of functions are confined within the limits of a single cell membrane.

It is obviously impossible within the twenty minutes allotted for this report to cover even in outline the whole of our knowledge of invertebrate hormonal mechanisms. The literature includes more than 1000 articles. Nor is there even time to discuss adequately the experimental evidence upon which our knowledge of a single endocrine gland (i. e. the insect corpora allata or crustacean sinus gland) is based. Instead, a middle pathway has been selected in which there will be an attempt to present a brief and summary account of our present picture of crustacean endocrines, their sources, and the functions which have been assigned to them. It is hoped that too much has not been attempted.

The Eyestalks and the Sinus Glands.— For many years it has been known that many higher crustaceans macroscopically blanch or darken their integument to correspond with the shade of the background upon which they come to lie. These color changes are principally the result of migrations of differently colored pigments within the bodies of highly branched integumentary cells called chromatophores. Any pigment which is dispersed into the branches and ultimate twigs of a chromatophore imparts its color to the general appearance of the animal; conversely, any pigment which is concentrated into a minute knot in the chromatophore center has little or no influence upon the gross

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coloration. By appropriate differential migrations of pigments of several colors a number of crustaceans may simulate more or less perfectly the tints of variously colored backgrounds. Many operative techniques involving cutting of nerves and consequent denervation of areas of the body of crustaceans have failed to interfere with the normal responses of the chromatophores concerned. Thus there is evidently no direct nervous control of these cells. Koller (1925, 1927) gave us evidence from blood transfusions that a blood-borne agent was responsible for certain of these chromatophore responses in the shrimp, Crago. Shortly thereafter, Perkins (1928) discovered that water extracts of the eyestalks of the shrimp, Palaemonetes, possessed the ability to concentrate dispersed red pigment strongly, thus blanching this animal. Extract of no other part of the body appeared to do this. Koller (1928) confirmed the presence in the eyestalks of Crago and of Leander of such a chromatophorotropic substance which produced strong concentration of their dark pigments. Koller further demonstrated that the eyestalk substance was not species-specific, but that eyestalk extract of Leander was effective upon Crago chromatophores and Crago eyestalk extract was effective upon Leander chromatophores.

During the following few years Kropp and Perkins (1933) tested many stalk-eyed crustaceans and discovered that all possessed such a substance in their eyestalks. Therefore this eyetalk substance which effected blanching of dark shrimp was of quite general occurrence.

In 1935 Carlson, and later in the same year Abramowitz, showed us that, contrary to the condition obtaining in shrimp, eyestalk extract of crustaceans produced dispersion of concentrated black pigment in the crabs, Uca and Portunus.

Meanwhile, Brown (1935b) had been examining in much detail the structure and responses of the chromatophore system of the shrimp, Palaemonetes. After learning that this animal possessed four pigmentary types (red, yellow, white and blue), all of which were able to react relatively independently of one another (even in a denervated area) when the animal was placed upon backgrounds, he concluded that the existence of at least four hormones was indicated to account for this complex behavior. This conclusion was unnecessary, as has been pointed out by Parker (1940), since three hormones, A, B and C, can be seen to yield seven combinations which could conceivably have as many qualitatively different actions on the chromatophore system. As a matter of fact, the absence of all three would provide an eighth possibility.

Abramowitz (1937a) believed that all of the responses of the chromatophore systems which had been described might be explained in terms of one principle which he called ESH (eyestalk hormone). He believed that differences in the effectors together with differing threshold responses would account for the complicated responses of the chromatophore systems. This theory he called the "unitary theory" in contrast to the "multiple theory" proposed by Brown. However, even on the basis of his own theory, Abramowitz failed to explain satisfactorily the complex behavior found in Palaemonetes (Brown, 1934-1935a) or Portunus (Abramowitz, 1935). Despite this, Abramowitz continued to uphold the theory that a single hormone was present in the eyestalk, and subsequently set about assaying and attempting to purify it (Abramowitz, 1937b).

Hanström (1933, 1934) had earlier described two gland-like bodies in the eyestalk of crustaceans, the blood gland and the X-organ (Dohrn, 1906). In 1935, by dividing eyestalks of various crustaceans transversely into thirds, he found a correlation between that third possessing the blood gland (later called the sinus gland) and that possessing the chromatophorotropic activity. He concluded upon this circumstantial evidence that the sinus gland was the source of the principle. This conclusion was confirmed by Brown (1940) who made extracts of isolated sinus glands and compared their activity both quantitatively and qualitatively with extracts of both whole and sinus glandless stalks. The sinus gland appeared to be the only eyestalk gland concerned in the reactions examined.

A year following the discovery of the chromatophorotropic activity of the eyestalk, Koller (1930) brought forth evidence that the eyestalk hormone was concerned with calcium metabolism in Crago, since eyestalkless animals pos-

sessed less calcium in their molted exoskeletons than did normal ones.

Another function ascribed to an endocrine originating in the eyestalks is the control of retinal pigment migration. The retinal pigments are located within the ommatidial complex and are typically classifiable into three groups: (1) the proximal retinal pigment, (2) the distal retinal pigment, which are light-absorbing melanins, and (3) the white reflecting pigment, guanin. These three pigments assume different positions in the compound eye in light and in darkness. In many crustaceans these pigments continue to show rhythmical diurnal movements even when maintained under constant conditions of light. Kleinholz (1936) brought forth clear evidence for endocrine control of certain of these pigments. Injection of eyestalk extract into a dark-adapted Palaeomonetes caused the distal retinal absorbing pigment and the white-reflecting pigment to assume the condition for light adaptation. The proximal retinal pigment, curiously enough, was unaffected. In 1938 Kleinholz concluded as did Hanström (1937b) that the hormone involved in this capacity must be different from those involved in integumentary pigment control since the retinal pigment activity was apparently quite independent of that of the integumentary chromatophores.

Welsh (1937) believed he had evidence that a principle originating in the eyestalk produced acceleration of heart rate in Cambarus, but during the following year performed other experiments which suggested that the effect was due to acetylcholine which could be extracted from crustacean nerve tissue quite generally. Scudamore (1941) however, presents evidence to prove that the sinus gland produces a principle which accelerates heart rate in the normal animal.

Another line of research has led to the conclusion that a hormone arising in the eyestalk is concerned with the control of molt and consequently is a factor influencing growth. Brown and Cunningham (1939) were able to accelerate molting rate by eyestalk extirpation and conversely were able to compensate partially for the effect of eyestalk removal by implanting sinus glands into the abdomens of the eyestalkless animals. Confirmation of molt acceleration following eyestalkectomy was obtained by Smith (1940), Abramowitz and Abramowitz (1940), and by Kleinholz (1940). Abramowitz and Abramowitz also showed a growth rate greater than normal. Unfortunately none of these later workers attempted implantation of eyestalk tissue, or extract injections, to determine whether the effects were actually the result of a hormone deficiency.

Brown (1938), Brown and Cunningham (1939) and Smith (1940) reported greatly decreased viability of Cambarus following eyestalk removal. The reason for this effect is still far from clear.

Finally, of the many functions ascribed to an eyestalk hormone, we might mention the control of blood sugar concentration (Welsh, 1941). Injection of eyestalk extract results in a sudden modification in blood sugar.

With all of the more or less well demonstrated functions of hormones arising in the eyestalks of crustaceans it appears highly improbable that we are dealing here with a simple gland secreting a single principle. This is particularly evident when we recall, for instance, the demonstrated relative independence of the four pigments of Palaemonetes in normal color change, and the independent behavior of the retinal pigments with respect to the integumentary pigments. It appears far more likely that a number of hormones are present.

The first successful attempt to demonstrate more than one active fraction from sinus gland was made by Brown and Scudamore (1940). They found that when dried sinus glands were extracted with 100 per cent ethyl alcohol a fraction entered the alcohol which showed qualitatively different chromatophorotropic properties from the fraction which was alcohol insoluble. Whereas extract of whole sinus gland strongly concentrated red pigment of Palaemonetes and strongly dispersed black pigment of Uca, the alcohol soluble fraction had almost no effect upon Uca black pigment while it had a strong effect upon Palaemonetes red. On the other hand, the alcohol insoluble fraction had a very strong dispersing action on Uca black but had a relatively weaker effect upon Palaemonetes red. Thus these results obviously could not be explained in terms of different concentrations of a single substance in the two fractions. A number of crabs and shrimp were examined and all

showed the presence of these two principles in varying proportions.

Central Nervous Organs.—It gradually became evident to certain of those working with crustacean chromatophores that the eyestalk was not the sole source of chromatophorotropic hormones. Eyestalkless animals showed chromatophore fluctuations and responses which could not be explained in other terms than variations in the concentrations of controlling hormones in the blood of these eyestalkless forms. Heterologous stimulation of the eyestubs of eyestalkless forms resulted in definite though transitory chromatophore responses by way of blood-borne agents. Brown (1933, 1935b) and Hosoi (1934) discovered that extracts of the nervous system of certain shrimp possessed chromatophorotropic activities. Kleinholz (1936) and Abramowitz (1937a) believed these effects were probably due to storage of an eyestalk principle in the central nervous organs. This explanation is quite untenable especially since the properties of this principle or complex of princiles has been shown to be unlike eyestalk extract, even affecting certain chromatophores, the guanophores, in quite the reverse manner.

It appears highly likely that certain diurnal chromatophore changes which are known to occur in eyestalkless Uca and Cambarus result from a periodic liberation of such a principle from the nervous system.

The Rostral Organ (Schwarz-Organ).—Koller (1928), after confirming the discovery of Perkins that the eyestalks yielded an extract which would produce rapid blanching of the shrimp, reported that an antagonistic substance originated in the rostral region of Crago. Injection of extract of this region resulted in a darkening of the shrimps. The source of this hormone Koller named the "Schwarz-organ". With the exception of Beauvallet and Veil (1934) no one has been able to confirm the presence of such a rostral organ in shrimp, even in Crago. The matter appeared conclusively settled by the work of Kleinholz (1938) who carefully reinvestigated Crago obtained at the same place as Koller's animals. Kleinholz found no evidence for a schwarz-organ.

Commissural Ganglia.—The shrimp, Crago, possesses a very complex pigmentary system containing at least eight physiologically or morphologically different pigmentary types (Brown and Wulff, 1941). Despite the fact that this shrimp had been one of those most frequently investigated, yet there seemed to exist a very inadequate picture of the mechanism of pigmentary control. During the summer of 1939, Brown and Ederstrom (1940) reinvestigated this species. The investigation was commenced since the apparent final elimination of the "schwarz-organ" by Kleinholz left certain responses of eyestalkless animals (Brown, 1939) quite without explanation. If the "schwarz-organ" of Koller was non-existent then another source of a pigment dispersing agent seemed essential to explaining certain observations. Brown and Ederstrom noticed that within an hour after the removal of the eyestalks of Crago the telson and uropods become completely blanched and normally remain so. Stimulation of the eyestubs or other harsh stimulation resulted in a rapid darkening of the "tail"; this darkening persisted for one half to one hour and then disappeared. This was demonstrated to result from the activity of a blood-borne agent. A thorough survey of body tissues finally resulted in localizing the source of the hormone involved in the ganglia upon the circumoesophageal commissures. This principle was shown to be present in greater quantity in the commissures of white adapted animals than of black adapted ones. Thus it was demonstrated to be concerned with normal color changes in this animal.

Further investigation of the control of Crago chromatophores by Brown and Wulff (1941) led to the clear conclusion that in Crago the commissural ganglia are apparently as important in the hormonally controlled color changes of this form as are the much more publicized sinus glands. A number of pigments within the integumentary chromatophores are affected in opposite directions by extracts from the two sources. Other pigments are affected in the same direction by the two, but to differing degrees.

Evidence has been obtained demonstrating that the commissural ganglia contain more than a single chromatophorotropic principle. Ethyl alcohol extracts of the ganglia yield a fraction which is very active in blanching the

trunk of Crago. The "tail-darkening" principle of the ganglia is alcohol insoluble and remains in the residue after brief alcohol extraction. The alcohol soluble fraction appears at the present time to be similar to the principle which is found in all of the central nervous organs of Crustacea.

It is interesting, from the comparative standpoint, that the "Crago-tail-darkening principle" has been found in the commissural ganglia of the other shrimp but not of the crabs examined. Furthermore, a sinus gland principle which antagonizes the action of the commissural ganglia in tail darkening is found in the sinus glands of the shrimps but not of the crabs examined. This appears to be one of the first bits of evidence (see also Kleinholz, 1936) that the endocrine complex is not uniform throughout even the decapod crustaceans.

The Gonads.—Despite the fact that the earliest suspected endocrine activity within crustaceans was probably respecting a hormone influencing the development and maintenance of certain secondary sexual characteristics, yet this is still today not adequately established. The early suspicions were based upon many observations that when a male crab was castrated through parasitization by a rhizocephalan such as Sacculina there was a strong tendency for the animal to take on the external characteristics of the female sex. One of the more popular of the interpretations of this phenomenon was that the animal, as a result of the castration, was deprived of the source of a male sex hormone. These results may, however, be equally well interpreted in terms of modification of the general metabolism, or of specific metabolic processes by the activities of the parasite. These modifications might secondarily influence the secondary sexual characteristics.

Somewhat better evidence for the hormonal activities of crustacean gonads has come from such experiments as those of Haemmerli-Boveri (1926) working with Asellus and Callan (1940) working with Leander. These authors report that destruction of the ovaries by X-radiation results in failure of development in the case of certain female external characteristics concerned with incubation of the developing eggs.

The sum of all the innumerable reports on the subject of determination of the secondary sex characteristics in Crustacea leaves one with the general impression that sex hormones are actually operative, but with little further idea as to the exact site of their formation or the extent of their action.

Definite demonstration of the presence of hormones concerned with the development of secondary and accessory sexual characteristics in crustaceans must be dependent upon the results of surgical removal of the hormone source and upon the results of effects of extracts or implants of this tissue source.

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THE ENDOCRINE FUNCTIONS OF THE MAMMALIAN OVARY*

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The complete expression of sexuality in the female involves the secretion of female sex hormones, ovulation, copulation and the birth of young. The internal secretions of the ovary regulate the sex accessories, the secondary sex characters and the mating reactions. Numerous factors in the external environment are known to influence the cyclicity of the female tract and it is probable that most of these effects are mediated by means of neuro-endocrine mechanisms. Not all of the genetic, endocrine, neural and nutritional phenomena involved in the control of ovarian functions have been elucidated, though substantial progress has been made in this direction during the last few decades. In natural environments there is a basic tendency for females to permit copulations only during recurrent periods when the best opportunities prevail in the female tract for the union of spermatozoa and eggs and for the differentiation of the zygotes.

In newborn mammals a large number of primary follicles are identifiable in the ovaries and, in certain species at least, there is evidence that this number is augmented by proliferations from the germinal epithelium during postnatal life. Only a small proportion of the original follicles ever complete their differentiation, the majority of them undergoing atresia without ovulating. As the individual approaches pubescence, certain of the ovarian follicles increase greatly in size and rupture in order to free their ova. The periodic release of eggs from the ovary is termed ovulation.

After ovulation the collapsed wall of the follicle undergoes rapid structural changes. The cells of the granulosa and, in most species, the cells of the theca interna enlarge, become fat-laden and highly vascularized, thus forming a compact body called the corpus luteum. If impregnation ensues, the corpus grows and persists functionally until near the end of gestation. In the absence of fertilization it persists for a shorter period which varies according to the species. The primary function of the graafian follicle is the nourishment and discharge of the ovum, but it is also associated with an incretory function. The corpus luteum seems to be entirely incretory and its secretion is distinct from that of the graafian follicle.

I. OVULATION

Ovulation is a complicated process involving both hormonic and nervous mechanisms. Only within recent years has experimental evidence made possible a satisfactory explanation of this phenomenon. Morphological studies indicate that the graafian follicle enlarges appreciably during proestrus and early estrus. Extensive mitoses occur in the follicular walls and the secretion of liquor folliculi distends the antrum. The cumulus oöphorus loosens and frees the ovum and its surrounding corona radiata. The tissue between the graafian follicle and the surface of the ovary thins out somewhat and an avascular area, the stigma, appears on the surface of the follicle. As the pressure within the antrum increases, the whole avascular area is caused to bulge. The weakest point on the avascular area bulges still further, producing a nipple or cone which finally ruptures. Slight hemorrhage into the antrum may precede rupture of the follicle. Direct observations indicate that rupture of the follicle is a non-explosive process somewhat similar to the breaking of an abscess. A small jet of thin liquor folliculi first spurts from the burst follicle but the remainder of the fluid is more viscous and leaves the follicle more slowly. Ovulation in the mammal requires less than a minute, whereas in the frog the release of an egg from the ovary occupies a period of from four to ten minutes.

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In the past there have been many unsuccessful attempts to explain ovulation on the basis of local changes in the graafian follicle and the adjacent wall of the ovary. Most of the earlier views held that ovulation resulted from increased intra-follicular pressure, supposedly brought about in various ways, or from the enzymatic dissolution of the follicular wall. While both of these may be important auxiliary factors, they are for the most part incidental. The modern view is that ovulation is a differentiational phenomenon which is initiated by the gonadotropic hormones of the anterior lobe of the hypophysis cerebri. During the past few years the following pertinent points have been established:

1. The administration of purified FSH produces huge cystic follicles which do not ovulate. Thus ovulation cannot be explained on the basis of increased secretion of liquor folliculi and a consequent elevation of pressure within the antrum.

2. Hypophysectomy prevents pre-ovulatory swelling and rupture of the graafian follicle.

3. Ovulation can be induced in a variety of vertebrates by the administration of a proper mixture of FSH and LH. A correct ratio between FSH and LH seems to be absolutely essential for the full expression of the ovarian follicle. While ovulation in the rabbit is conditioned normally by cervical stimulation, it may be induced in normal or hypophysectomized subjects in the absence of sexual excitement by the administration of both FSH and LH. This seems to justify the assumption that ovulation is a growth phenomenon which occurs only in the presence of the proper anterior lobe principles.

4. Ovulation is not dependent upon the nerve supply to the ovaries. Normal ovulation may occur in ovarian grafts and in intact ovaries deprived of all nervous connections when the proper hypophyseal hormones are present.

5. The release of the ovulatory hormones from the anterior pituitary is almost certainly regulated by means of nervous pathways. Rabbits continue to copulate after surgical section of the infundibular stalk but ovulation does not occur in these animals. Under these conditions ovulations can be induced by the administration of FSH and LH. In normal estrous rabbits ovulation may be induced by electrical stimulation of a certain area in the pre-optic region of the brain, but this becomes impossible after section of the infundibular stalk. An increasing amount of evidence justifies the assumption that the secretion and/or release of ovulatory principles from the anterior hypophysis is controlled by nerve fibers which extend to it from the hypothalamic region of the brain stem.

The continued removal of eggs from the nests of certain birds may prolong the period of egg-laying very appreciably. In the light of what is known about ovulation in other vertebrates, one might suppose that this response is affected by means of a neural mechanism which prolongs the release of gonadotropins by the hypophysis rather than by a direct nervous stimulation of the ovaries. Endocrinologists are just beginning to appreciate the possibility that stimuli originating in the central nervous system may profoundly modify the functional states of endocrine glands.

II. THE OVARIAN HORMONES

A. The estrogenic hormone of the graafian follicle.—The first experiments leading to the identification of the ovarian hormones were attempts to prevent castration atrophy in the female by means of transplanting ovarian tissue. Near the turn of the present century, several investigators demonstrated that castrate atrophy of the uterus could be prevented by incorporated ovarian grafts. These first experiments demonstrated clearly that the atrophic changes following castration resulted from the withdrawal of an ovarian secretion rather than from nervous disturbances.

During the next few years there were attempts to develop desiccated preparations and ovarian concentrates which would be as effective as subcutaneous ovarian grafts in correcting the syndrome resulting from castration. At this period, the ovary was regarded as performing an incretory function but the ovarian secretion was conceived of as a single substance. While Adler's work was unconvincing, he claimed in 1912 that he was able to prepare aqueous extracts of ovarian tissue which had the property of restoring some degree of sexual activity in spayed females.

The next observations of importance were detailed histological studies of the ovary and the female accessories during the course of the normal cycle. It became possible to correlate ovarian changes with differences in the sex accessories and secondary sex characters. The estrous cycle of the guinea pig was described in minute detail in 1917 by Stockard and Papanicolaou (1). Similar studies were made on the rat by Long and Evans (2) and on the mouse by E. Allen (3). These observations were extremely significant since they suggested that the graafian follicle is the source of the estrogenic hormone, and since they indicated sensitive physiological indicators for the assay of estrogens. In these laboratory rodents, it was determined that a rhythmic sequence of changes occurred in the vagina and that these changes, followed by the vaginal smear technique, corresponded to rhythmic modifications of the ovary. Following oöphorectomy the vaginal rhythm ceases and the diestrous condition prevails.

The final physiological identification of an ovarian hormone awaited the epochal experiments of Allen and Doisy (4). These workers aspirated liquor folliculi from the vesicular follicles of fresh sow's ovaries and injected it into oöphorectomized mice and rats. Within fifty hours subsequent to the injection of fresh liquor folliculi, or alcoholic extracts of the fluid, to spayed animals the vaginal smear contained cornified epithelial cells typical of normal estrus. Histological examination of the sex accessories indicated that the vaginal wall had attained maximal growth, the superficial layers being cornified as during estrus. The uteri were hyperaemic and distended with fluid. Following withdrawal of the injections, the castrate condition supervened. When administered to immature rats and mice these extracts produced premature canalization of the vagina. The property of estrogenic substances to produce cornification of the vagina of the spayed rat or mouse was adopted as a simple and accurate method of bioassay.

Frank (5), using castrate mice as test animals, demonstrated that an estrogenic substance having the same properties as follicular fluid was present in menstrual and circulating blood of the human female. During pregnancy the amount in the blood was increased. In 1928 Zondek (6) reported that large amounts of estrogen were present in the urine of pregnancy. This was a timely discovery inasmuch as the urine from pregnant women and mares provided a cheap source of tremendous amounts of estrogen for chemical studies. This substantial background of animal experimentation culminated quickly in the chemical isolation and purification of the follicular hormone and chemically related estrogens.

During the 1920s many investigators believed that the ovary secreted only one hormone, i. e., estrogen. Here was a substance which fulfilled many of the functions ordinarily attributed to the ovary. Since it appeared likely that estrogen, when properly purified and physiologically tested, would substitute completely for the ovaries in castrate rodents, there seemed to be little incentive to look further for additional ovarian hormones. Other workers, however, remained skeptical and insisted that it was necessary to account for certain observations which had been made during the first decade of the present century.

B. The Hormone of the Corpus Luteum.—Long before any experimental evidence became available, there were many speculations regarding the function of the corpora lutea. Beard in 1897 suggested that the corpora lutea constituted an "organ of pregnancy" and speculated that this organ exerted an inhibitory influence upon ovulation and that it prolonged the cycle. Born (1900) was aware that the corpora lutea attained maximal differentiation during the period when blastocysts were ready to implant in the uterine mucosa and when the placental connections were being established. He indicated to his student, Ludwig Fraenkel, that he believed that the corpora lutea produced a substance which prepared the uterus for the reception and inplantation of the developing embryos. Born died before having opportunity to test experimentally his hypothesis and Fraenkel (7) proceeded to do so. Fraenkel bilaterally oöphorectomized rabbits immediately after mating, or removed the corpora lutea from mated individuals, and found that under these conditions implantation and pla-

centation did not ensue. He found that the removal of the corpora lutea previous to the twentieth day of pregnancy resulted either in absorption or abortion of the young.

Additional evidence that the corpora lutea are important in conditioning uterine reactions was provided by the classical experiments of Leo Loeb (8). He allowed estrous guinea pigs to mate with vasectomized males and, several days later, laparotomized the females and traumatized the uteri. He found that a tumor of decidual cells differentiated at the sites where the uteri were injured. This indicated that the corpora lutea produce the hormone which makes it possible for the endometrium to undergo decidual changes in response to the irritating effect of the blastocysts. Loeb (9) demonstrated also that extirpation of the corpora lutea hastened the next estrus and that removal of other parts of the ovary did not give this effect. Later it was found that ablation of the corpora during pregnancy might be followed by ovulations. On the basis of these early experiments, many believed that the corpora lutea secreted the ovarian hormone and that this was the only hormone concerned in the reproductive cycle.

Ancel and Bouin (10) extended Loeb's work to include the pseudo-pregnant rabbit. Since ovulation in this species occurs ten hours subsequent to copulation or cervical stimulation, luteinization can be induced in the absence of pregnancy by artificially stimulating the cervices or by mating with a vasectomized male. These two French investigators found that during pseudopregnancy the uterus underwent a type of proliferation which simulated that normally occurring during pregnancy. They found that this type of uterine growth, now designated as progestational proliferation, did not occur after the ablation of the corpora.

Herrmann (11) prepared lipoid extracts of corpora lutea and placental tissue and showed that they produced uterine growth and congestion.

In 1921, it was reported that corpora lutea could be shelled out of the ovaries of the non-pregnant cow by means of rectal palpation. This procedure was followed within two days by ovulation and estrus.

The chain of evidence establishing the incretory function of the corpus luteum was completed by Corner (12) and his collaborators. These workers prepared lipoid extracts of corpora lutea obtained from the ovaries of pregnant swine and found that such extracts produced progestational proliferation in the uteri of castrate adult rabbits, a reaction which cannot be elicited by estrogen alone. The recognition of this physiological endpoint in the rabbit was as instrumental in the isolation of the luteal hormone as was the vaginal response of the mouse and rat in the physiological identification of estrogen. These extracts, administered to rabbits which had been castrated eighteen hours after fertile matings, maintained pregnancy to term. They sensitized the uterus so that decidual reactions resulted from uterine trauma and, in short, produced all of the effects which earlier experiments indicated as attributable to the corpus luteum. The active extract of the corpus luteum was named "progestin". By 1933 several groups of investigators had announced the isolation of the hormone in crystalline form. Shortly thereafter, it became possible to synthesize the hormone of the corpus luteum, progesterone, from stigmasteral and from pregnanediol.

C. Androgenicity of the Mammalian Ovary.—There is substantial evidence indicating that the ovary may become capable of liberating appreciable amounts of androgen during unusual or abnormal circumstances. Steinach and Kun (13) reported that the luteinized ovaries of the guinea pig may exert masculinizing effects. Lipschütz (14) found that an ovarian graft persisting for three years in a castrate male guinea pig had restored fully the seminal vesicles and prostatic glands of the host. The experiments of Hill and collaborators (15, 16) indicate that ovarian homotransplants into the ears of castrate mice frequently become capable of maintaining secretion in both the seminal vesicles and prostate. A similar androgenic action of ovarian grafts persisting in the ears of rats has been reported by Deanesly (17). She did not find that the androgenicity of the ovarian grafts was conditioned by temperature as Hill maintains for mice.

Several workers have shown that crystalline progesterone produces masculinizing effects. It has not been proved,

however, that the chemical configuration of the progesterone molecule is not altered by the organism before androgenic effects are elicited. Nelson (18) found that progesterone resembled androgens inasmuch as it was capable of maintaining spermatogenesis in the gonads of hypophysectomized rats. Turner (19) described a spontaneous lesion of the rat's ovary which rendered it hyper-estrogenic and definitely androgenic. The absence of corpora lutea provided presumptive evidence that the masculinizing action of these ovaries was not due to progesterone.

The identity of the androgenic substances which derive from ovaries has not been ascertained. While the administration of large amounts of progesterone elicits masculinizing effects in certain laboratory rodents, the evidence seems to indicate that the ovaries may librate another androgenic compound which is similar to but not identical with that secreted by the testis. Deanesly found that gonadotropins causing extensive luteinization of the granulosa did not alter appreciably the androgenicity of the ovarian ear grafts in the rat. From studies upon the growth curves of male accessory glands, Hill and Strong concluded that the physiological response induced by ovarian grafts in the ears is not nearly duplicated by the experimental administration of testosterone propionate plus estrogens.

On the basis of studies undertaken in this laboratory, we believe that the androgenicity of the ovary is correlated with hypertrophy and hyperplasia of the theca interna of follicles which are forced experimentally to become atretic. In the case of ovaries persisting in the ears of castrate males, the hypophysis stimulates the differentiation of many vesicular follicles. These cannot ovulate because of an improper endocrine balance in the male and because of the complete encapsulation of the graft by dense tissue. When the cords of epithelioid cells derived from the theca interna persist and become abundant the ovary is made capable of secreting enough androgen to maintain secretion in the male sex accessories.

A permanent impairment of the rat's hypophysis and ovary results from the daily administration of 100 IU of estrogen during the first ten days of postnatal life. The follicles become atretic before reaching full maturity. The thecal cells become epithelioid and persist after other elements of the follicles have deteriorated. Some of the ovaries from adult animals of this type induce secretion in the seminal vesicles and prostate when such gonads are transplanted to the kidneys of long-time castrate male hosts. Since both kidney and ear grafts sometimes possess androgenic potencies, it appears that the temperature of the transplantation site is not the principal factor determining the androgenicity of the ovary.

In conclusion, an attempt has been made to present evidence upon which a modern theory of ovulation is based, and to outline the major events which led to the physiological identification of the ovarian hormones. Evidence has been presented which indicates that the ovary, under certain conditions at least, may secrete a male-sex-hormone-like compound which seems not to be progesterone.

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CHARLES ZELENY

1878-1939

CHARLES ZELENY died in December 1939 after an illness of four years. He was born of Czech parents at Hutchinson, Minnesota, and was one of five brothers, three of whom have had distinguished careers in science. He studied at the University of Minnesota and Columbia University, and took the doctorate in zoology at the University of Chicago in 1904. After five years at Indiana University he came to the University of Illinois in 1909 where he taught zoology and was active in research until his death. He was head of the department of zoology and chairman of the division of biological sciences from 1933 to 1937.

He was a professor in the strict sense of the word because to him, science was a faith and a way of life rather than a profession or an occupation. A keen student of experimental biology, he was extremely cautious and careful in analyzing data and drawing conclusions and had a passion for seeking out alternative explanations. He believed that the mechanistic viewpoint was the most productive approach to biological problems and that quantitative research would establish biology as an exact science comparable to the physical sciences. Perhaps his greatest delight was in simple, clear-cut experiments which gave definite answers to questions concerning the internal mechanisms of living things.

As a young man his principal research was an analysis of the factors involved in regeneration and he became known for his establishment of the principle of compensatory regulation in the organism. He maintained his interest in regeneration and the localization of developmental factors in the fertilized egg and spent many summers in later years experimenting with serpulids and other marine invertebrates at the Naples and Woods Hole biological stations. In 1914 he received a stock of the bar mutant of Drosophila which occupied his attention and that of many of his research students for twenty-five years. He learned that selection had its effect by sorting out and accumulating definite germinal differences. He made the first measurements of the rates of mutation within a single series of multiple allelomorphs and, with his research students, analyzed in detail the effect of temperature and other environmental factors on the somatic manifestation of this bar series of multiple allelomorphs.

Mild-mannered and kindly, he had an unusually wide circle of friends. He was greatly interested in international affairs and was saddened by the approach of the present war. He was an ardent and skilled outdoorsman and made many trips into the north woods with his family or a crony or two.

DAVID H. THOMPSON.

EUGENE RICHARD DOUGHERTY

1902-1940

ON NOVEMBER 4th, 1940, the Academy lost an esteemed member. Though his affiliation with our society was of relatively short duration his wholehearted efforts as Vice-President and Chairman of the Local Committee, at the time of the Springfield meeting, as well as his contribution to the scientific papers in the section of Zoology, entitle him to special recognition at this time.

Mr. Dougherty was born in Beaver Falls, Pennsylvania, June 22, 1902. After graduating from Beaver Falls High School he attended Geneva College, in Beaver Falls. He was graduated from St. Louis University in 1928 with a bachelor's degree. Graduate studies were pursued at St. Louis University and the University of Buffalo.

In 1934 Mr. Dougherty became associated with Springfield Junior College. Springfield, Illinois, in the capacity of instructor in Biology. In 1939 he was promoted to the position of Dean.

It was in connection with the Springfield Meeting (1938) of the Academy that Mr. Dougherty first took an active part in the organization. His generous services in making arrangements for that meeting are gratefully remembered by officers and members alike.

Mr. Dougherty's untimely death occurred suddenly following a brief illness. He is survived by his wife, Flora Pullinger Dougherty.

GILBERT WRIGHT.

A TRIBUTE IN MEMORY OF ROSE M. CASSIDY

In the passing of Miss Rose M. Cassidy on January 8, 1941, the Illinois State Academy of Science has lost one of its most loyal members.

Miss Cassidy was a graduate of the University of Michigan, and later took advanced work at the Universities of Chicago, Utah, Wisconsin and Notre Dame. For the past twenty-three years she has been a member of the Science Department of the Maine Township High School.

Miss Cassidy became a member of the Illinois State Academy of Science organization in 1930, in the same year that the Maine Chemistry Club, which had recently been organized under her sponsorship, became affiliated with the Junior Academy of Science. In the very early phase of the existence of the Junior Academy, she was among the first to recognize its possibilities and was ready to assume responsibilities and to give a vast amount of time and energy to constructive. work in its development.

Through the Maine Chemistry Club Miss Cassidy was able to demonstrate the foundation principles and ideals upon which the Junior Academy movement was based. In this club under her faithful guidance were fostered scientific imagination, originality, and invention, together with accuracy in learning and skill in technical procedures. Here, also, the pleasure of scientific creative activity was enhanced by the healthy competition with other clubs in the annual exhibit of the Junior Academy. The success of Miss Cassidy as a sponsor and leader is shown in the record that the club received highest honors in the Chemistry Division of the annual exhibits for seven of the past ten years.

Miss Cassidy was made chairman of the Chemistry section in the Junior Academy for 1932-1933 and again in 1933-1934. She was then appointed to serve as co-chairman of the Annual Competition 1934-1935 and in the following year, 1935-1936, she served as co-chairman of the Junior Academy. In 1936 she was chosen the Illinois editor for Science Aid Service, the official organ of the cooperating Junior Academies of Science, in which capacity she served with distinction during the past four years.

At the annual meetings of the Junior Academy she displayed unusual talent as an executive. Her plans were well formulated and the staff of helpers well chosen while she in person directed the work, giving the timely word or active help wherever it was needed.

Miss Cassidy never ceased to be a student. She read widely in fields of science, world affairs, poetry and art,— sources from which she derived inspiration for daily work. She transmitted to her pupils appreciation of the beauties of nature which she had learned from her father, a great nature-lover, with whom in her earlier years there was a great companionship. From her mother, gifted in music, she learned beauty in rhythm and in exquisite techniques.

Although gifted in many lines, Miss Cassidy found her greatest joy in work with young people, where she watched youthful minds develop methods of scientific thinking with a measure of creative genius appearing under the guidance of this gifted sponsor. In her home, open evenings to club members, programs were planned and projects organized by committees from the Maine Chemistry Club.

With a humility of spirit often found in the truly great she devoted time and energy to the development of cultural ideals in the lives of her pupils. Honesty and integrity were incorporated into her teaching along with methods for transmuting scientific dreams into forms of reality. She had assumed responsibilities from her early youth and worked with all her great fund of energy to put order into the lives of those about her. She loved the world and she loved people and was never without deep interests in science and in humanity. These interests which might have been only a pleasant pastime to be put aside and forgotten as the years passed, grew with her and enriched her life.

Miss Cassidy belonged to several scien-

tific organizations. For many years she was a member of the Illinois Association of Chemistry Teachers. While in the West she was a member of the Sierra Club. The beauty of the Western canyons inspired her to a study of the plant life of those regions and for a number of years she helped to organize this material and to make collections for the Smithsonian Institute.

At one time in her college dramatics, she was asked to select a drama suitable for presentation by the club. She unearthed an Elizabethan treasure full of rich humor and appealing traits of character. Her interest led her to continue this search until she had the nucleus of a volume which was shared and published by an English teacher. This study was a contributing factor in her love and admiration for the British people.

In the memorial address for Miss Cassidy, Rev. Dr. Walter D. Spangler quoted from several of her favorite poems. A quotation from a poem by Henry Wadsworth Longfellow aptly describes the life of Miss Cassidy as her friends and coworkers in the Junior Academy have known her.

"Among the many lives that I have known,
None I remember more serene and sweet,
More rounded in itself and more complete,
Than hers, who lies beneath this funeral stone.
These pines that murmur in low monotone,
These wal[illegible] frequented by scholastic feet,
Were all [illegible]er world; but in this calm retreat
For her [illegible]eacher's chair became a throne.
With fo[illegible]d a[illegible]ection memory loves to dwell
On the [illegible]'d [illegible]ays, when her example made
A pastime of the toil of tongue and pen;
And now amid the groves she loved so well
That naught could lure her from their grateful shade,
She sleeps, but wakes elsewhere, for God hath said, Amen."

Always she used her mind, was a cheerful companion, high spirited and fearless, reaching out for what was fine and beautiful, and scorning what was base.

The sympathy of members of The State Academy of Science is extended to the bereaved family.

To Miss Minnie C. Cassidy I am grateful for collaboration in the preparation of this paper.

ROSALIE M. PARR.